housing is configured to macroscopically alter its physical shape in response to the shape input.

[0024] FIG. **1** is a block diagram illustrating a portable device **600** capable of providing kinesthetic effects in accordance with embodiments of the present invention. Device **600** includes a housing **602**, a display **604**, a keypad **606**, and extensions **608-0** and **608-1**. In another embodiment, keypad **606** is part of a touchscreen display **604**. Device **600**, in one embodiment, is a wireless portable system capable of providing wireless audio/video communication, mobile data communication, remote game console, and the like. For example, device **600** may be a cellular phone, a PDA, a smart phone, a laptop computer, a game console, and/or a handheld electronic device capable of processing information as well as providing haptic feedback.

[0025] To provide a haptic feedback to a user's hand in accordance with an operation mode, device **600** is capable of macroscopically altering its outer enclosure or housing **602** (which includes extensions **608**) in response to the nature of the application. Depending on the application, extensions **608** can expand or contract (as indicated by arrows in FIG. **1**) thereby macroscopically altering the shape and/or size of housing **602**. In one embodiment, a shape is "macroscopically" altered if it changes to the extent that the change can be detected by the user via, for example, sight or feel. For example, a cell phone device capable of changing its outer enclosure shape may be used to emulate a handshake between two users. To convey a handshake, a first user, for instance, might squeeze its first shape changing phone to cause a pulse or squeeze of a second shape changing phone of a second user, where the first and second users are engaged in a telephone call via the first and second shape changing phones connected to the first shape changing phone. In other words, a shape input or shape signal is sent from the first shape changing device to a second shape changing device indicating that the second device should activate its haptic mechanism to change its shape for emulating a handshake. In other embodiments, additional portions of device **600** besides housing **602** may also change shape, such as display **604**, or input elements such as keypad **606**.

[0026] Systems such as device **600** may employ vibrotactile effects and/or kinesthetic effects to emulate shape changing effects. Vibrotactile effects, for instance, may be used to incorporate haptic feedback to a user via a handheld device. Such haptic feedback effects may be characterized by relatively high-frequency (e.g., about 160-220 Hz) and relatively small displacement (e.g., about 50-500 micrometers) vibrations. Further, different types of haptic information such as confirmation of button clicks and alerts can also be conveyed. Kinesthetic effects, on the other hand, may be characterized by relatively large displacements (e.g., about 1-10 mm) and relatively low-frequency (e.g., about 10-40 Hz) motions. Deformable or flexible surfaces can be used for effective emulation of kinesthetic effects, such as macroscopically changing surface properties depending on the application or activated feature.

[0027] Kinesthetic effects may be effectively emulated using deformable haptic surfaces. For example, kinesthetic effects may allow a handheld device to be used as a directional navigation tool. In this example, activation of deformable surfaces at different locations on the handheld device can be used as a haptic display of directional information. In another example, kinesthetic effects allow performance of specific effects (e.g., pulsation, heartbeat, etc.), which could be of value in virtual tele-presence and/or social networking applications. In one example, a heartbeat of one person can be emulated by expanding and contracting deformable pads on the sides of a cell phone of another person connected via a telephone call. In another example, a squeezing of a cell phone at one end of a call can be emulated as a handshake sensation at another cell phone at the other end of the call.

[0028] Force haptic effects or "force effects" may be emulated using various types of input signals to drive a haptic actuator, such as, but not limited to, an eccentric rotating mass ("ERM"). Certain types of input signals may be used to provide various impulse force effects or a "jerk sensation" as opposed to more constant force effects (e.g., pushing or pulling force effects). In one example, such impulse force effects may simulate being poked by a finger. In one example, such impulse force effects may simulate a strike, for example, of a golf club impacting a golf ball. In one example, such impulse force effects may simulate a racket impacting a tennis ball. Impulse force effects may be used to simulate other gaming environments.

[0029] Device **600**, in one embodiment, is able to change shape based on an operating mode (e.g., application, activated feature, etc.), as opposed to merely being manipulated by a user. Various haptic materials and/or actuators can be used in the haptic mechanism to cause varying shapes in a flexible surface of device **600**. For example, electroactive polymers ("EAPs") may be used to form one or more actuators in the haptic mechanism for shape changing based on activation of control signals. In other embodiments, a piezoelectric element, programmable gels, or a fiber of shape memory alloys ("SMAs") can be used as actuators.

[0030] In one embodiment, indications of a device operating mode such as an activated feature and application can activate predetermined patterns of a haptic mechanism. Such patterns can then be applied to the flexible surface of device **600** using a deformation mechanism. A haptic substrate that includes a plurality of actuators can be applied to the surface to enact or form the patterns. EAPs, for example, can be employed to form one or more actuators in a haptic mechanism such that activating signals received by the haptic mechanism can convey flexible surface shapes. The haptic substrate can be formed from micro-electro-mechanical systems ("MEMS") elements, thermal fluid pockets, MEMS pumps, resonant devices, variable porosity membranes, laminar flow modulation, etc.

[0031] Extensions **608** can be controllable as to displacement, as well as any pulsation or other suitable effects and/or patterns. For example, one user can squeeze a first device, and a second device connected on a call to the first device can pulse or squeeze in the hand of a second user to convey a physical handshake. Thus, a signal can be sent from the first device to the second device to indicate that the second device should change shape to emulate a handshake (e.g., a low frequency force or pressure like a squeeze of a hand). In this fashion, any predetermined shape change characteristics or patterns supportable by the underlying haptic mechanism, substrate, and/or actuator control can be employed.

[0032] FIGS. **2***a*-**2***b* are block diagrams illustrating portable handheld devices (**700**, **750**) in accordance with embodiments of the present invention. Device **700** can be used as a directional navigation tool (e.g., using the global positioning system ("GPS")), in which activation of deformable surfaces **704-0** and **704-1** at different locations on the device can be used as a haptic display of directional informa-